DESCRIPTION AND AGE SIGNIFICANCE OF *M. HERCYNICUS* TYPE MONOGRAPTIDS FROM EILDON, VICTORIA

By William B. N. Berry

Museum of Palaeontology, University of California, Berkeley

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Monograptids of the *M. hercynicus* type have been recovered from the lowest part of the Wilson's Creek Shale and possibly the stratigraphically highest part of the Eildon Group on the slopes of Mt Sugarloaf at Eildon, Victoria. The monograptids found are assignable to two distinct forms, one of which may only be a highly distorted version of the other. The undistorted form is a new species. It was found in beds at the same stratigraphic level with those bearing *Baragwanathia* and also in those bearing hyolithids at a higher stratigraphic level. The same new species is being described by Jaeger from the *Baragwanathia*-bearing beds at the well-known 19 Mile Quarry locality on the Yarra Track.

Monograptids of the *M. hercynicus* type are at present known to occur only in strata of post-Ludlow age. The new species found at Eildon is considered to be indicative of a Gedinne age. Whether the Gedinne Stage belongs in the Silurian or Devonian System is a matter of

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ERRATUM

p. 424, line 30 should read—

'fauna of the inland plains of New South Wales has virtually disappeared during the'

CORRIGENDA

p. 494, line 4 of Appendix 1, after 'identifications' insert—

'of limb bones; otherwise, throughout the appendix, the identifications'

p. 496, line 8, delete 'one of *Thylacinus*,'

described as occurring with, or at the same locality as, *Baragwanathia* by Lang and Cookson (1935) and Harris and Thomas (1937) led him to suggest that these forms may be monograptids of the *M. hercynicus* type. Since that time, he has been engaged in a study of actual specimens of these forms from the 19 Mile Quarry locality on the Yarra Track and other monograptids of this type from that and other localities in Victoria. Jaeger (1962a, b) commented upon his initial examination of some of these specimens and will soon publish the results of his study of collections sent to him.

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Monograptids of the *M. hercynicus* type have been recovered from the lowest part of the Wilson's Creek Shale and possibly the stratigraphically highest part of the Eildon Group on the slopes of Mt Sugarloaf at Eildon, Victoria. The monograptids found are assignable to two distinct forms, one of which may only be a highly distorted version of the other. The undistorted form is a new species. It was found in beds at the same stratigraphic level with those bearing *Baragwanathia* and also in those bearing hyolithids at a higher stratigraphic level. The same new species is being described by Jaeger from the *Baragwanathia*-bearing beds at the well-known 19 Mile Quarry locality on the Yarra Track.

Monograptids of the *M. hercynicus* type are at present known to occur only in strata of post-Ludlow age. The new species found at Eildon is considered to be indicative of a Gedinne age. Whether the Gedinne Stage belongs in the Silurian or Devonian System is a matter of debate among students of the boundary between these Systems. The author favours a Devonian position for it, and thus the *M. hercynicus* type monograptid-bearing beds at Eildon are considered Early Devonian in age. Further, they are considered correlative with the *Baragwanathia* and *M. hercynicus* type monograptid-bearing beds at the 19 Mile Quarry locality.

Introduction

Although *Monograptus hercynicus* and another monograptid of the same type, *M. kayseri,* were described by Perner in 1899, monograptids of this kind have been little cited in geologic literature until the studies made by Pribyl (1942) and Jaeger (1959). Indeed, Jaeger's work on monograptids of this sort has stimulated a considerable widespread interest in them, particularly from the point of view of their age significance, and they have recently been recognized in a number of parts of the world. Jaeger (1959, p. 84-86) summarized several of the known occurrences to that time and, since then, Jackson and Lenz (1963) have described a new species of the *M. hercynicus* group from the Yukon area in Canada, and Jaeger and the author have recognized monograptids of this group from the central part of Nevada in the United States and from the Gaspe Peninsula in E. Canada. Jaeger has also recognized monograptids of this type in collections from Poland and other areas in central Europe as well.

The possible occurrence of monograptids of this group in Australia was first noted by Jaeger (1959, p. 84-85) when he commented that his examination of figures of *Monograptus uncinatus* var. *orbatus* and *M. uncinatus* var. *micropoma* described as occurring with, or at the same locality as, *Baragwanathia* by Lang and Cookson (1935) and Harris and Thomas (1937) led him to suggest that these forms may be monograptids of the *M. hercynicus* type. Since that time, he has been engaged in a study of actual specimens of these forms from the 19 Mile Quarry locality on the Yarra Track and other monograptids of this type from that and other localities in Victoria. Jaeger (1962a, b) commented upon his initial examination of some of these specimens and will soon publish the results of his study of collections sent to him.

While examining graptolite collections at the National Museum of Victoria, the author came across a small collection of monograptids of the *M. hercynicus* type made by Mr E. D. Gill. The collection was obtained from beds exposed in a trench cut into the bedrock of the southerly slope of Mt Sugarloaf near Eildon, Victoria at the time Dr D. E. Thomas was studying the geology of the Eildon area prior to construction of the present Eildon Dam and reservoir. Anxious to obtain more of these monograptids, the author and Mr Gill made a trip to Eildon in August 1963 and collected a relatively large number of graptolites from the south-western side of Mt Sugarloaf. The recovery of these forms was recorded by the author (1964) in a short note.

Acknowledgements

The author is indebted to Mr E. D. Gill for taking him to the Eildon area and collecting there with him, for turning over for study the collection initially made by him, and for many discussions concerning Victorian Siluro-Devonian stratigraphy. The author thanks Dr John Talent for giving him the pertinent publications on the geology and palaeontology of the Eildon area and for his many helpful discussions and letters concerning the stratigraphic and age problems in that area. The author is also deeply indebted to Dr Hermann Jaeger for examining specimens from Eildon and for considerable help with the determination of them. Both the author and Dr Jaeger have studied the 19 Mile Quarry specimens in some detail but, as Dr Jaeger has been working with and writing about these forms since 1959, he will, in another publication, describe the 19 Mile Quarry specimens and name the new species which occurs both there and at Eildon. In the course of correspondence between Dr Jaeger and the author concerning the identity of the 19 Mile Quarry and Eildon area monograptids, both have agreed that the same new species of monograptid of the *M. hercynicus* type is present in both areas.

Age Significance of M. hercynicus Type Monograptids

Monograptids of the *M. hercynicus* type are among the youngest monograptids known. Perner (1899, p. 11) noted that the two species he described came from the f_1 beds of the Bohemian Lower Palaeozoic succession and that the age of these beds might well be Devonian. Despite that early reference of these kinds of monograptids to beds of possible Devonian age, monograptids have commonly been considered to be restricted in their range to the Silurian, and that the youngest part of the Silurian might be denoted by the last monograptid. Indeed, Jaeger (1959), in his discussion of Thuringian monograptids of the *M. hercynicus* type, indicated the age of the beds from which they came as Latest Silurian. In a subsequent work, however, he (1962a) discussed the correlation of these and other German and the Bohemian strata bearing *M. hercynicus* type monograptids with the typical Ludlow Series (Late Silurian) deposits in Wales and the Gedinne and Siegen Stages. He showed (1962a, p. 127) that *M. hercynicus* may range into beds as young as Siegen age and that other monograptids of the *M. hercynicus* type which occur stratigraphically below *M. hercynicus* in Germany and Bohemia were restricted in their range to beds of post-Ludlow and probable post-Silurian age.

The placing of the Gedinne with the Devonian is open to some debate among students of the Siluro-Devonian boundary and its problems. As discussed by Jaeger (1962a), if the top of the Ludlow be considered the top of the Silurian and the Ludlow be correlated with the $e\beta_1$ beds in the Bohemian succession and the Malinovetzki Beds in Podolia, and if the correlation of the Borszezow Beds in Podolia and the basal part of the Lochkov Limestone (the $e\gamma$ beds) of the Bohemian succession with the Gedinne be accepted, then in both Podolia and Bohemia, fossiliferous beds lay between those correlated with the top of the Ludlow and those with the base of the Gedinne. These are the $e\beta_2$ beds of the Bohemian sequence and the Skala Beds of Podolia. Boucot and Pankiwskyj (1962) designated a new Stage, the Skala Stage, to encompass these beds and that part of the geologic succession lying between rocks correlated with the Ludlow and those correlated with the Gedinne. As Boucot and Pankiwskyj (1962) pointed out, the fauna of the Skala Stage is typified by the presence of a few characteristically Devonian elements such as certain terebratuloid brachiopods and it lacks many diagnostic Silurian elements. It may thus best be included in the Devonian. The fauna of the Skala Stage is considered transitional in character between those of the Ludlow and Gedinne Stages and as such to typify a new time-stratigraphic unit between these two.

Some students of the Siluro-Devonian boundary wish to include all monograptid-bearing rocks in the Silurian. If this is done, then rocks bearing monograptids of the *M. hercynicus* type and shelly fossils that permit correlation with the Skala, Gedinne, and at least lower part of the Siegen Stages, the $e\beta_2$ beds and the Lochkov Limestone in Bohemia, for example, would be placed in the Silurian. The shelly faunas in these beds are Devonian in aspect and permit correlation with Devonian systemic sub-divisions.

If the shelly fossils be relied upon for recognition of the Siluro-Devonian System boundary, as they have been for recognition of the sub-division of these Systems, then the Skala Stage may be considered the basal Stage of the Devonian. If this be done, then the appearance of monograptids of the *M. hercynicus* type may be taken as diagnostic of the lower part of the Devonian. This monograptid group makes its first appearance in beds correlative with the Skala Stage and seems to have been derived from the older, typically Ludlow age *M. uncinatus* group.

The matter of the position of the Skala and Gedinne Stages and their correlatives in the Devonian is thus a subject of some debate among students of the typical areas of the Silurian and Devonian. In this work, the author will follow the suggestions and use of Boucot (oral communications 1962-64) and refer the Gedinne and Skala Stages and their correlatives to the early part of the Devonian.

The *M. hercynicus* type monograptid described by Jackson and Lenz from the Yukon came from strata interbedded with those bearing a brachiopod and coral fauna. The brachiopods in this fauna were studied by Johnson and Boucot who concluded (in Jackson and Lenz 1963, p. 752) that they indicated a 'post-Ludlow and probably early Gedinnian' age. The *M. hercynicus*-bearing beds in central Nevada occur stratigraphically above those bearing a brachiopod fauna concluded by Johnson and Boucot (written communications 1961-62) to be of Early Devonian age. Further, the *M. hercynicus* type monograptids from the Gaspe Peninsula in E. Canada occur above beds bearing a shelly fauna concluded by Boucot to be of Early Devonian age. The monograptids from this area are *M. aequabilis,* which Jaeger (written communications 1963-64) concludes only occurs in Early Gedinne age beds in central Europe. Nikiforova and Obut (1960) listed *M. hercynicus* as occurring in strata in central Asiatic Russia with brachiopods that suggest a possible Gedinne age.

In summary, in all areas in which monograptids of the *M. hercynicus* type have been found with or in close association with shelly fossils, the shelly fossils have been interpreted to be of post-Ludlow and, in the sense of this work, Early Devonian age. Further, monograptids of this type are at present known to be restricted in their range to beds herein considered of Early Devonian age. For these reasons, an occurrence of *M. hercynicus* type monograptids is now concluded by the author to be evidence of an Early Devonian age for the beds bearing them wherever found, until such time as this age span may be increased. Jaeger's (1962) careful study of the European correlations of the graptolite-bearing strata with the Stage and Series of the Devonian and Silurian which are based upon shelly fossils, and the Devonian age interpretation of the shelly fossils that occur with or below *M. hercynicus* type monograptids are considered by the author as reasonably conclusive evidence in favour of this contention.

The Eildon Collections

Stratigraphic Position

The graptolites collected by Mr Gill and the author came from three different stratigraphic levels. The stratigraphically lowest collection was made at the southwestern end of a large quarry face cut into the southerly slope of Mt Sugarloaf which rises above the western side of the Eildon reservoir. A few fragmentary nautiloids and a specimen of *Baragwanathia* were also obtained at the same stratigraphic level. The other collections were made from outcrops on the road southwest of the quarry face. The road trends northeasterly toward a nearby boat harbour. The two stratigraphically higher collections came from the western side of the road in exposures southwest from those in the quarry. The stratigraphically highest collection was obtained in the topographically uppermost part of the road cut. It contained some hyolithids as well as graptolites. The stratigraphically medial collection came from approximately 10 ft beneath the highest. This contained only graptolites, but the largest number of specimens are present in this collection.

The original collection made by Mr Gill from the slopes of Mt Sugarloaf could not be accurately located relative to those made by the author with Mr Gill. The trenches that Dr Thomas had cut to enable his geologic studies of the area appear (from plan No. 14301 in Thomas 1947) to have been cut primarily across the beds depicted on that plan as the Eildon beds. One trench did extend a considerable distance into what is depicted as Plant-Graptolite Beds on that plan. Mr Gill's notes suggested that the collection might have been obtained from the northeastern slope of Mt Sugarloaf. From his discussions with Mr Gill, the author is of the opinion that the original collection came from the steeper slopes of Mt Sugarloaf, from beds depicted in the plans included in Thomas's (1947) report on the geology of the area as Eildon beds. Two graptolite forms were recognized in each of the three collections made by the author with Mr Gill's aid and the same two forms are present in the original collection made by Mr Gill.

The assignment of the strata from which the monograptids collected and studied by the author came to a stratigraphic unit is a matter that is, to some extent, open to differing opinions. Without doubt, the two stratigraphically higher collections obtained by Mr Gill and the author came from those strata designated by Thomas (1947, p. 16) as the Plant-Graptolite Beds. These strata were also termed (Thomas 1947, p. 16 and Plans 14302, 14312, and 14315) the *Uncinatus* Beds and the *Baragwanathia-M. uncinatus* Beds.

The stratigraphically lowest of the three collections made by the author with

Mr Gill also came from the Plant-Graptolite Beds. The author, however, is of the opinion that the graptolite-bearing rocks which fall within the lowest part of the Plant-Graptolite Beds are so folded that they may be traced into the stratigraphically highest strata of that unit designated by Thomas (1947, p. 16) as the Eildon Beds. This opinion was that intended to have been made by the author (1964, p. 223) in his earlier note. This point, however, was not clearly expressed there. In the author's opinion, the lowest part of the sequence shown by Thomas (1947, Plan 14315 'Geological Sections 2-2′ & 3-3′ Through Sugarloaf') as 'Thin bedded Black Mudstones and Sandstones' of the '*Baragwanathia-M. uncinatus* Beds' is the lateral equivalent, now folded, of the uppermost part of the Eildon Beds designated 'Mainly fine grained Sandstones & thin Mudstones' by Dr Thomas (1947, Plan 14315, Geological Sections 2-2′ and 3-3′). The author's opinion is derived from his examination of the exposures in the quarry face on the southerly side of Mt Sugarloaf. These excellent exposures were not available to Dr Thomas in the course of his geological investigation of the area and hence his opinion on this matter could not be expressed at the time he completed his report. Despite the fact that these exposures were not available to him, his mapping and diagrams are interpreted by the author as suggesting the possibility of such folding. Further, despite the lack of such well-exposed outcrop, Dr Thomas's section (1947, Plan 14315, Geological Section 2-2′) drawn approximately through the same position on Mt Sugarloaf that the present quarry face is now located, is remarkably similar in detail to the contorted nature of the beds revealed by this quarry excavation subsequent to his investigation. The author's opinion on the lateral equivalency of the highest part of the Eildon Beds with the lowest part of the Plant-Graptolite or *Baragwanathia-M. uncinatus* Beds is not shared by members of the Geological Survey of Victoria nor by the Geology Department of the University of Melbourne (Talent, written communication 1964).

In the author's opinion, the original collection made by Mr Gill came, with reasonable probability, from the upper, or 'Mainly fine grained Sandstones & thin Mudstones' part of the Eildon Beds as depicted in Geological Section 2-2′ in Plan 14315 by Thomas (1947). Because the author is of this opinion, because he believes that the lowest part of the Plant-Graptolite Beds (*Baragwanathia-M. uncinatus* Beds) are lateral equivalents of the highest part of the Eildon Beds, and because the same graptolites were recovered from these strata as well as from stratigraphically higher strata clearly within the lower portion of the Plant-Graptolite Beds, the stratigraphically highest part of the Eildon Beds is interpreted to be virtually of the same age as the stratigraphically lowest part of the Plant-Graptolite Beds. The strata involved in this age interpretation are only those from which graptolites have been obtained. No implication is intended for any others. The graptolite-bearing rocks are not precisely the same age, for superposition obviously makes the stratigraphically lower ones older than those stratigraphically above. Within the limits of refined age determination permitted by the fossil evidence, however, and with due cognizance of the age differences imposed by superposition, the graptolite-bearing strata are of approximately the same age.

Thomas (1947, p. 16) noted that the Plant-Graptolite Beds and the underlying Eildon Beds, as well as the Upper Sandstone Beds which overlay the Plant-Graptolite Beds, were a part of the 'Jordan River Beds (and Donnellys Creek Beds)'. Later, Thomas (1953, p. 27) published the chart reproduced here as Table 1 which suggests that the Plant-Graptolite Beds had been named the Wilson's Creek Shale and the Eildon Beds, the Eildon Group.

TABLE 1

Taken from Thomas (1953, p. 27) with addition of the column showing age interpretation of graptolite-bearing rocks of this study

<table>
<tr><th rowspan="2">Age of graptolite-bearing rocks of this study</th><th colspan="2">Thomas (1953)</th><th>—</th><th colspan="2">Thomas 1947</th></tr>
<tr><td rowspan="2">Jordan River Group</td><td>Norton's Creek Sandstone</td><td>Tanjilian</td><td>Upper Sandstone Group</td><td>Tanjilian (in part at least)</td></tr>
<tr><td>? ↑ ? Gedinne — ? —</td><td>Wilson's Creek Shale</td><td>Melbournian</td><td>Plant-Graptolite Beds (shown on the plans accompanying Memoir 16 as Baragwanathia-M. uncinatus beds)</td><td>Melbournian</td></tr>
<tr><td>Skala and older</td><td></td><td>Eildon Group</td><td></td><td>Eildon Beds</td><td>?Eildonian</td></tr>
</table>

Age of the Eildon Collections

PREVIOUS INTERPRETATIONS

The age of the beds from which the graptolites were collected by the author and Mr. Gill at Eildon would appear from the chart (Table 1) to have been correlated with the Melbournian in part in the past. The age of the highest part of the Eildon Group of this chart was left in question. In regard to local Silurian subdivisions and their correlation, Thomas (1960, p. 13) stated that 'four subdivisions of the Silurian are recognized in Victoria and they are correlated with the Silurian of Britain as follows:

	Victoria	Britain
4	Tanjilian	Upper Ludlow
3	Melbournian	Lower Ludlow
2	Eildonian	Wenlock
1	Keilorian	Llandovery'.

Philip (1960) discussed these subdivisions of the Silurian in Victoria and indicated (Fig. 2, p. 146) that although the Keilorian equivalency with the Llandovery or Valentian and that of the Eildonian with the Wenlock had been relatively consistent throughout the use of these terms by various authors, some range of opinion existed concerning the equivalency of the Melbournian and the Tanjilian with the British sequence, and indeed with each other, in part, as well.

The original age assignment of the beds from which the author and Gill's graptolite collections were obtained would appear to have been latest Eildonian (or Wenlock) and earliest Melbournian (or Ludlow) in age from Philip's (1960) and Thomas's (1947, 1960) discussions of the correlation of the local subdivisions of the Silurian in Victoria with the British Series of the Silurian.

The recognition of the Eildonian as a local time subdivision of the Silurian in

Victoria has been discussed by Philip (1960, p. 145) as follows: 'Thomas (1947) recognized a further subdivision of the Silurian of Victoria in the Eildon district in the northern part of the Walhalla Synclinorium. This stage, designated the "Eildonian", occurs stratigraphically above Keilorian beds containing *Monograptus exiguus* and below plant-graptolite beds of Melbournian age. The subdivision then is roughly equivalent to the Wenlockian. No graptolites have been found in Eildon Beds, but a small tabulate coral fauna from a limestone horizon within the unit was determined by Hill (1947) who concluded that the fauna was Upper Ludlow in age'. Philip (1960, p. 149) also pointed out that, in his opinion, Hill's age interpretation of the corals from the Eildon Beds was somewhat younger than he might interpret them. Hill (written communication 1963) indicated that she would still favour the Late Ludlow age interpretation expressed in 1947.

This discussion by Philip and the chart included in Thomas's (1947, p. 16) report on the geology of the Eildon Dam area led the author to indicate (1964, p. 223) that Thomas had designated the Eildon Beds as typical of the Eildonian Stage and to further suggest the possibility that a part of that stage might be correlated with the Early Devonian Gedinne Stage. Talent (written communications 1964) has pointed out to the author that Dr Thomas never specifically designated a type locality or area for the Eildonian Stage. The first mention of the term Eildonian in the category of a Silurian subdivision appears in the work on the Eildon area, and the Eildon Beds are questionably referred to that subdivision, yet a type section or area was not then and has not been definitively denoted. The subdivision is considered to be a correlative of the Wenlock in Britain, and thus the graptolite-bearing beds related to the uppermost part of the Eildon Group by the author must be younger than the age of the Eildonian on the basis of the author's age interpretation of the graptolites.

Some fragmentary graptolites were described by Harris and Thomas (1948) from the Eildon Beds but they do not permit a close, refined age determination for the strata from which they came. Both the author (1964, p. 223) and Philip (1960, p. 145) were in error in stating that no graptolites had been described from the Eildon Beds for Harris and Thomas (1948) did describe and figure a few fragmentary dendroids and one monograptid collected from the Eildon Beds mapped by Thomas (1947, locality 13 on Plan 14303) on the eastern slope of Mt Pinninger. The graptolites collected by the author and Mr Gill are the first specifically identifiable forms to be described and interpreted for their age significance from strata possibly belonging in the Eildon Group exposed on Mt Sugarloaf.

This Study

The graptolites described herein are monograptids of the *M. hercynicus* type. As monograptids of this type have formerly only been found in beds of Early Devonian (or at least post-Ludlow) age, the rocks from which the collections made by Mr Gill and the author came are considered to be post-Ludlow and Early Devonian in age. Jaeger (written communication 1964) has stated that he identified a species of the *M. hercynicus* type known to occur only in Early Gedinne age beds in a collection sent to him by Talent. The collection bearing this species was reported to have come from about 3500 ft below the 19 Mile Quarry beds that bear *Baragwanathia* and the same new species of monograptid of the *M. hercynicus* type as that found by the author in his and Mr Gill's collections from the basal part of the Wilson's Creek Shale and possibly the uppermost part of the Eildon Group at Eildon. The rocks bearing the new species of monograptid of the *M. her-*

cynicus type thus appear to be of Gedinne and probably Late Gedinne or possibly even younger age, in the opinion of both Jaeger and the author.

On the basis of this evidence, the author concludes that the lower part of the Wilson's Creek Shale and possibly the highest part of the Eildon Group exposed on Mt Sugarloaf, those beds and only those beds from which graptolites were obtained, are of Gedinne and possibly Late Gedinne or younger age. The fossil evidence suggests that the beds from which the graptolites were collected on the slopes of Mt Sugarloaf may be correlated with at least those beds bearing *Baragwanathia* and the new species of *Monograptus* of the *M. hercynicus* type at the 19 Mile Quarry locality.

If the correlation of the local Silurian subdivisions in Victoria noted by Thomas (1960, p. 13) and Philip (1960, p. 146, Fig. 2) be followed and the Melbournian, at least in part, is correlative with the Early Ludlow and the Tanjilian with the Late Ludlow, then the basal part of the Wilson's Creek Shale and possibly the highest part of the Eildon Group on the southwestern slopes of Mt Sugarloaf must be younger than either the Melbournian or the Tanjilian. If the Yeringian at least in some part, is correlative with the Gedinne, then, in terms of the local systemic subdivisions in Victoria, the basal part of the Wilson's Creek Shale and the stratigraphically highest part of the Eildon Group on the slopes of Mt Sugarloaf are correlative with that part of the Yeringian that may be correlated with the Gedinne. Further, Philip (1960, p. 155) noted the monograptids Jaeger (1959) considered to be of the *M. hercynicus* type occur associated with *Baragwanathia* 'at the base of the Tanjil Beds and their equivalents'. If the *Baragwanathia* and monograptid-bearing part of the Tanjil Beds occurs within the Tanjilian, then that part of the Tanjilian is a correlative of the Gedinne. If that be the case, then at least a part of the Tanjilian may be correlated with a part of the Yeringian.

Systematic Descriptions

Two forms of monograptids of the *M. hercynicus* type are present in collections made by Mr Gill and the author from the slopes of Mt Sugarloaf. One form is relatively long and slender compared to the other. Most of the slender forms lie in one direction which appears to be that of maximum movement during deformation of the rocks in which they are entombed. The slender forms in general lie parallel to each other and at right angles or a high angle to the wider, shorter forms.

As Jaeger (1959, p. 69-77) has discussed, many monograptids may be so severely deformed during deformation of the rocks in which they are entombed that length and width may be markedly changed from their original state and even thecal number and characteristics changed noticeably. Indeed, Jaeger (1959, p. 73) noted among rhabdosomes of the same species of monograptid that those rhabdosomes lying parallel to the axis of greatest movement had a thickness of about 2 mm and 12 thecae in 10 mm, whereas those rhabdosomes that lay at right angles to this axis had a thickness of about 3 mm and 16 thecae in 10 mm.

All the rhabdosomes encountered in the present study may well belong to the same species, with the longer ones having been subject to strong deformation, whereas the shorter and wider ones have been preserved with more nearly their original dimensions. Jaeger (written communication 1964) is of the opinion that both of these forms belong to the same species.

The wider forms lie at many angles to the slender forms, but never parallel to them. A few do lie at an 8 to 10 degree angle to the slender forms. The dimensions of each form are such that each falls within a group of specimens distinct from the other. Even among those wider specimens lying at low angles to the slender ones, no evidence of intergradation between the two groups was observed. For this reason, the two forms may be phyletically distinct. For the present, however, they will be described as two different forms of the same species with the realization that they may be two distinct species or that they may be perhaps more probably, merely two differently preserved forms of the same species. The shorter, wider, and less deformed form is designated Forma A, and the slender, elongated form is designated Forma B.

Class GRAPTOLITHINA Bronn 1846
Order GRAPTOLOIDEA Lapworth 1875
Suborder MONOGRAPTINA Lapworth 1880
Family MONOGRAPTIDAE Lapworth 1873
Genus **Monograptus** Geinitz 1852

The writer follows the suggestion made by Bulman (1963, p. 416) in retaining the broad generic grade *Monograptus* as a general portmanteau in descriptive studies of graptoloids with uniserial scandent rhabdosomes until such time as phylogenies and lineages within the grade may be established.

Monograptus sp. nov. (of the *M. hercynicus* type) FORMA A

(Pl. 1, fig. 1-11; Pl. 2, fig. 7-9, 11; Fig. 1a, b)

MATERIAL: 8 complete and 45 fragmentary rhabdosomes. Some of the rhabdosomes are preserved in low relief whereas others are highly compressed and crushed.

FIG. 1a, b—Proximal ends of *Monograptus* sp. nov. (of the *M. hercynicus* type) Forma A (×10) showing the isolate nature of the apertural hooks or hoods of the proximal thecae and Th 1 in particular and the detail of the sicula aperture with its ventral spine and dorsal projection. These proximal end features are diagnostic ones of this new species. Nat. Mus. of Vict. Reg. No. P23100.

DIAGNOSIS: Rhabdosome commonly has broad, gentle S-shape with dorsal curvature in proximal 1·5-2·0 mm, then bending to ventral curvature in the next 4-8 mm, then bending gently back to broad dorsal curvature in most; 13-23 mm long; 0·9-1·1 mm wide at first thecal aperture (measured with thecal hood) and width increases to maximum of 1·8-2·1 mm (with thecal hood); thecae of *uncinatus* type (as described by Jaeger 1959, p. 86), more strongly hooked in proximal portion than in distal, 10-12 in 10 mm; sicula narrow in upper part but widens markedly in lower part, 1·5-1·8 mm long and 0·5-0·6 mm wide at aperture.

Description: Most of the rhabdosomes of this species have a broad S-shape. The proximal 1·5-2·0 mm is bent dorsally, then the rhabdosome curves sharply to the ventral side and the next 1-3 mm is marked by a pronounced ventral curvature. The ventral curvature becomes less pronounced farther away from the proximal end, but the next 4-8 mm of each rhabdosome taken distally from the proximal dorsal curvature is curved ventrally. Distally from the ventral curvature, most rhabdosomes have a broad, gentle dorsal curvature which encompasses the remainder of the length of the rhabdosome. Some rhabdosomes become straight in the distal part and are not curved, and two had a slight dorsal curvature followed by a slight ventral curvature in their distal portions. In general, however, the gentle S-shape characterizes most rhabdosomes.

The rhabdosomes are relatively short, a few complete ones measuring but 12-13 mm in length. Most of the complete rhabdosomes have lengths of 15-23 mm. The longest of the rhabdosome fragments are 19-21 mm long and are very nearly complete, thus suggesting that rhabdosome length did not exceed 25 mm at most.

The rhabdosomes are 0·9-1·1 mm wide at the first theca, the width including the thecal hook or hood. The width at the first theca without the hook or hood is 0·6-0·7 mm. The rhabdosomes widen to 1·0-1·3 mm without the thecal hook and 1·3-1·6 mm with the thecal hook or hood at 5 mm from the sicula aperture and to 1·4-1·8 mm without the thecal hook or hood and 1·6-2·1 mm with the thecal hook or hood at 10 mm from the sicula aperture. At 15 mm from the sicula aperture, the rhabdosomes are 1·4-1·8 mm wide without the thecal hook or hood and 1·7-2·0 mm wide with the thecal hook or hood. The widths attained at 15 mm are maintained throughout the remainder of the rhabdosome. The greater widths are seen in the more compressed specimens and, in some of them, the width may be slightly (0·1 mm) greater at a given distance than the range indicated. The lesser widths cited are those of specimens preserved in low relief.

The thecae are of the *uncinatus* type. The proximal 7-12 thecae are more strongly hooked than are the distal thecae. The hooks or hoods (hauben in the sense of Jaeger 1959, p. 79) are pronounced on the proximal thecae but they are but small, slender tubes that are but weakly hooked in the distal portions of the rhabdosomes. The hooks in the initial two thecae appear to project out from the ventral wall very prominently, making these thecal hooks more isolate from the rhabdosome than any others.

The thecae number 5½-6½ in the initial 5 mm and 10½-12½ in the initial 10 mm. They number 10-12 in distal portions of the rhabdosome.

The strongly hooked thecae in the proximal region, at a distance greater than 4 mm from the sicula aperture, are 1·8-2·2 mm long and they are free 0·7-0·8 mm. They are 0·6-0·8 mm wide measured vertically between the near-horizontal portions of the interthecal septa. The hooked part of the thecae is 0·2-0·3 mm wide and the hood or free hook is 0·4-0·5 mm high. The height of the hood is measured as the vertical distance from the level of the thecal aperture to that of the point of maximum curvature. The interthecal septum of these thecae has a sloping portion that is 0·6-0·8 mm long and commonly makes an angle of approximately 30° with the rhabdosome axis and a more nearly horizontal portion that is 0·4-0·6 mm long and is at a 20-32° angle with the horizontal. The angle between the two parts of the interthecal septum is 145-155°.

The thecae in the distal portions of the rhabdosome are characterized by having but very small hooks. These thecae are 1·9-2·1 mm long measured diagonally from the aperture to the innermost part of the interthecal septum. They overlap almost their entire length with only the hooked part being free. The free ventral wall of these thecae is straight, 0·6-0·8 mm long, and it makes an angle of 10-20° with the vertical. The thecal hooks project horizontally from the ventral side of the rhabdosome and they are 0·2-0·4 mm long and but 0·1-0·15 mm wide. The interthecal septum has an S-shape. Its ventral part is horizontal and is 0·3-0·4 mm long. This part bends to a sloping portion that is 0·4-0·5 mm long and makes an angle of 15-25° with the rhabdosome axis. The inner or dorsal part is 0·3-0·4 mm long and makes a 20-30° angle with the horizontal.

The sicula is 1·5-1·8 mm long and is 0·25-0·35 mm wide at its aperture. In specimens in which the proximal end has apparently been distorted, the upper 0·8-1·0 mm of the sicula is a narrow cone, but the lower part of the sicula widens and has a relatively broad, open conical shape. Such siculae are 0·5-0·6 mm wide at their apertures, and they have a general resemblance to siculae of *M. hercynicus*.

The sicula aperture has a relatively broad projection on the dorsal side which is 0·5-0·7 mm long. A slender spine 0·2-0·4 mm long extends from the ventral side of the sicula aperture.

Remarks: These forms resemble *M. praehercynicus* but, in general, are shorter and somewhat more curved in rhabdosome shape than that species. The thecal hooks or hoods of the first two thecae are more prominent and isolate in this form than in *M. praehercynicus,* and the sicula in this form has a dorsal projection which siculae of *M. praehercynicus* do not have. Further, the number of thecae in 10 mm may be slightly greater in this form than in *M. praehercynicus.*

Specimens identical with these have been recognized by the author in collections from beds bearing *Baragwanathia* from 19 Mile Quarry. This opinion has been corroborated by Jaeger's (written communication 1964) work on the 19 Mile Quarry specimens and his examination of a small collection from the Eildon area.

Monograptus sp. nov. (of the *M. hercynicus* type) Forma B

(Pl. 2, fig. 1-6, 10, 11)

Material: 5 complete and 26 fragmentary rhabdosomes. Some of the rhabdosomes are preserved in low relief whereas others are highly compressed and crushed.

Diagnosis: Rhabdosome with dorsal curvature in proximal 1·5-2 mm, bending to ventral curvature for next 5-9 mm and then straight thereafter; 22-32 mm long commonly and one specimen is 41 mm; widens from 0·9-1·1 mm at first thecae (measured with thecal hood) to a maximum of 1·1-1·2 mm; thecae of *uncinatus* type, more strongly hooked in proximal portion than in distal, 8-9 in 10 mm; sicula narrow and conical, 1·8 mm long and 0·3 mm wide at aperture.

Description: 4 of the 5 complete rhabdosomes have lengths in the span of 22-32 mm and the fifth is 41 mm long. The proximal 1·5-2·0 mm of the rhabdosome is bent slightly to the dorsal side. This slight dorsal curvature takes place in the distance of the length of the sicula. A bending toward the ventral side takes place either at or within 0·3-0·5 mm of the sicula apex. The ventral curvature of the rhabdosome encompasses the next 5-9 mm of the rhabdosome length. It is more pronounced in the proximal 2-3 mm of its expression and becomes gradually less pronounced. Those portions of the rhabdosome distal from the ventral curvature are straight and the distal portions of the rhabdosome are characterized by their straight and almost parallel-sided appearance.

The rhabdosomes are 0·9-1·0 mm wide at the first thecal aperture. This width is measured with the width of the hooked portion of the theca included. The width at the first theca without this portion included is 0·5-0·75 mm. The rhabdosome width at 5 mm from the sicula aperture is 1·0-1·2 mm with the width of the hooked portion of the nearest theca included and 0·5-0·95 mm without this part of the theca included. The width at 10 mm from the sicula aperture is 1·1-1·3 mm with the hooked part of the nearest theca included and 0·9-1·1 mm without that part of the theca. The rhabdosome width at 15 mm from the sicula aperture is 1·0-1·2 mm with the hooked part of the nearest theca included and 0·9-1·1 mm without that part of the theca. The widths at distances of 20, 25, 30, and 35 mm from the sicula aperture fall within the same span as those at 15 mm. The rhabdosome width without the hooked part of the theca thus is constant from 10 mm from the sicula aperture throughout the remainder of the length of the rhabdosome in most of the specimens studied. In a few, this width is attained at 6-7 mm from the sicula aperture and remains the same throughout the remainder of the rhabdosome.

The thecae, in general, are of the *uncinatus* type. The proximal 8-12 thecae have strongly developed hooks (hauben in the sense of Jaeger 1959, p. 79) and the prominence of the hooks diminishes markedly beyond these proximal thecae so that the distal ones have but weakly developed hooks.

The thecae commonly number 7¾-8½ in the initial 10 mm, but a few specimens have 9 and a few others have 10 thecae in the same part of the rhabdosome. At distances greater than 15 mm from the sicula aperture, the thecae number 8-9 in 10 mm.

The thecae in the span of 4-10 mm from the sicula aperture are 2·3-2·5 mm long, and 0·4-0·5 mm wide, and they overlap 0·9-1·1 mm. The thecae are essentially tubular in aspect. Where they become free at the ventral margin of the rhabdosome they immediately curve into an open inverted U-shaped form. The thecal aperture appears to be essentially horizontal. The perpendicular distance from the aperture to the level of the base of the U-shape or point of maximum curvature is 0·4-0·6 mm. The thecal aperture is 0·2-0·3 mm in diameter or in maximum dimension, and the curved part of the thecae is 0·2-0·25 mm wide. The hooked part of the thecae in this part of the rhabdosome extends 0·2-0·4 mm from the ventral rhabdosome wall in most thecae and may extend as much as 0·7 mm in a few thecae. Such thecae appear to have been more highly deformed and compressed than the others. The medial part of the interthecal septum in this part of the rhabdosome is straight, 0·4-0·55 mm long, and is oriented at a 17-22° angle to the rhabdosome axis. Its dorsal portion turns to within 8-20° of horizontal and that part is 0·1-0·2 mm long.

The distal thecae, those beyond 15 mm from the sicula aperture, have much less pronounced hooks or hauben, and the hooked part of the thecae is commonly closely pressed to the ventral part of the rhabdosome. The thecae are 2·5-2·8 mm long and 0·3-0·4 mm wide. (The length is measured diagonally from the top of the hook to the base of the theca.) The thecae overlap 2·3-2·5 mm. The